

Utilization of Lightweight Materials Made From Coal Gasification Slags

Quarterly Report
September 15 - November 30, 1994

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1.0 PROJECT OBJECTIVE AND TASK DESCRIPTION

Coal gasification technologies are finding increasing commercial applications for power generation or production of chemical feedstocks. The integrated-gasification-combined-cycle (IGCC) coal conversion process has been demonstrated to be a clean, efficient, and environmentally acceptable method of generating power. However, the gasification process produces relatively large quantities of a solid waste termed slag. Regulatory trends with respect to solid waste disposal, landfill development costs, and public concern make utilization of slag a high-priority issue. Therefore, it is imperative that slag utilization methods be developed, tested, and commercialized in order to offset disposal costs.

In previous projects, Praxis investigated the utilization of "as-generated" slags for a wide variety of applications in road construction, cement and concrete production, agricultural applications, and landfill. We determined that it would be extremely difficult for "as-generated" slag to find acceptance in the marketplace even at no cost because the materials it could replace were abundantly available at very low cost. It became apparent that a more promising approach would be to develop a variety of value-added products from slag that would meet specific industry requirements. This approach was made feasible by the discovery that slag could be made into a lightweight material by heating it to between 1600 and 1900°F in a kiln, which indicated the potential for using such materials as substitutes for lightweight aggregates. Between 1987 and 1993, the technologies to produce these materials from slag were developed by Praxis with funding from the Electric Power Research Institute (EPRI), Illinois Clean Coal Institute (ICCI), and internal resources.

This project aims to demonstrate the technical and economic viability of the slag utilization technologies developed by Praxis to produce lightweight aggregates (LWA) and ultra-lightweight aggregates (ULWA) from slag in a large-scale pilot operation, followed by total utilization of these aggregates in a number of applications.

The scheduled date for commencement of Phase I of this project was 15 September 1994, and the schedule end date is 14 December 1995. The scheduled start date for Phase II is 15 December 1995, and the scheduled end date of the project is 14 March 1997.

1.1 Scope of Work

The slag will be physically processed by screening and char removal, followed by thermal or pyroprocessing to produce a large batch of expanded slag aggregates of various size gradations and unit weights, ranging from 12 to 50 lb/ft³. The aggregates will then be tested for their suitability in manufacturing precast concrete products (e.g., masonry blocks and roof tiles) and insulating concrete, first in laboratory tests and subsequently in commercial manufacturing plants, using ASTM and industry test methods. Technical data generated during the production and testing of these products will be used to assess the overall technical viability of the approach. Data on the processing costs of expanded slag aggregates will be gathered for comparison with management and disposal costs for slag or similar wastes in order to assess the economic viability of these utilization technologies. Following this, the manufactured end-products will be

evaluated for suitability in their respective applications. In addition, a market assessment will be made using data obtained from market surveys and product samples generated to establish market prices for expanded slag products. These will form the basis of the overall economic evaluation studies.

1.2 Task Description

The project objectives will be achieved in two phases, each lasting fifteen (15) months. The tasks to be performed in Phase I are as follows:

- Task 1.1 Laboratory and Economic Analysis Plan Development: This task involves development of a detailed work plan for Phase I and an outline of the Phase II work.
- Task 1.2 Production of Lightweight Aggregates from Slag: This task involves selection and procurement of project slag samples, slag preparation, and expansion in direct- and indirect-fired furnaces. Preliminary laboratory-scale studies will be conducted before bulk samples of expanded slag are collected for processing. In this task, the char recovered from the slag preparation operation will be evaluated for use as a kiln fuel and gasifier feed.
- Task 1.3 Data Analysis of Slag Preparation and Expansion: This task involves analysis and interpretation of the project data. Material and energy balances will be developed for the slag preparation and expansion process. Environmental data will be collected during preparation and expansion of slag.
- Task 1.4 Economic Analysis of Expanded Slag Production: This task entails conducting a complete economic analysis of the utilization of expanded slag. Costs for production of slag LWAs and ULWAs will be determined. An estimated market value will be established for the various expanded slag products. A comprehensive economic evaluation will be made by comparing the production costs of slag aggregates with the costs associated with disposal and management of slag as a solid waste.
- Task 1.5 Topical and Other Reports: This task involves preparation and delivery of topical, financial status, and technical progress reports as per the requirements in the Statement of Work.

The Phase II effort will focus on utilization of the expanded slag aggregates in various applications. A test plan will be developed detailing all the activities in Phase II. Field studies will be conducted on expanded slag aggregates to test their performance as substitutes for conventional materials in various applications, including masonry blocks, roof tiles, insulating concrete, and insulation fill. Mix designs will be formulated and tested by refining the material proportions used in previous work. Commercial-scale practices and standards, equipment, and techniques will be used for this work. New applications will be identified during the course of this

work. The Phase II data and economic evaluation will primarily consist of extending and refining the analyses conducted in Phase I.

1.3 Scope of this Document

This is the first quarterly report, prepared in accordance with the project reporting requirements, and covers the performance period from 15 September through 30 November 1994. This report provides a summary of the work undertaken during this period, highlighting major achievements.

2.0 SUMMARY OF WORK DONE DURING THIS REPORTING PERIOD

2.1 Summary of Accomplishments

The following accomplishments were achieved during this reporting period:

1. A Project Work Plan was developed detailing the laboratory and economic analysis plan for Phase I and outlining the work to be done in Phase II.
2. A kickoff meeting was held at DOE-METC to present the work plan for final approval.
3. Slag sample selection and procurement was initiated. An advance sample was shipped to Penn State for screening and char removal.
4. Laboratory-scale tests were conducted to prepare the slag for expansion, including a tabling operation for char removal.
5. Drying of prepared advance sample slag product and laboratory-scale pyroprocessing work was also initiated.
6. Analytical techniques were developed to analyze the data obtained from laboratory- and pilot-scale tests.

2.2 Chronological Listing of Significant Events

Date	Description
09/15/1994	Project commencement date
10/24/1994	Draft "Laboratory and Economic Analysis Plan" prepared and submitted
11/15/1994	Kickoff meeting held
11/07/1994	Advance slag sample collected from Eastman Chemical Company and sent to Penn State University
11/18/1994	Tabling operation on advance sample completed and prepared slag sent to Fuller and Silbrico for expansion
12/02/1994	Final "Laboratory and Economic Analysis Plan" prepared and submitted

3.0 TO DATE ACCOMPLISHMENTS

This section documents the work completed in the first quarter of the project, which is also the work accomplished to date.

Date	Accomplishment
10/24/1994	Draft "Laboratory and Economic Analysis Plan" prepared and submitted
11/07/1994	Advance slag sample collected from Eastman Chemical Company and sent to Penn State University
11/18/1994	Successful tabling operation on advance sample completed and prepared slag sent to Fuller and Silbrico for expansion
12/02/1994	Final "Laboratory and Economic Analysis Plan" prepared and submitted

4.0 TECHNICAL PROGRESS REPORT

4.1 Laboratory and Economic Analysis Plan Development

As part of Task 1.1, Laboratory and Economic Analysis Plan, a comprehensive testing and economic analysis plan was developed which will be used as a technical guideline during Phase I. This plan included the following:

- ▶ Detailed plan for bench- and pilot-scale experimental work and economic analysis for Phase I
- ▶ Quantities of slag required for the test work under each task
- ▶ Data to be gathered during testing
- ▶ Approach to data analysis
- ▶ Approach to economic analysis
- ▶ Outline of the work plan for Phase II
- ▶ Detailed project schedule (Phases I and II) for all tasks and subtasks
- ▶ Detailed breakdown of labor hours by tasks for the entire project
- ▶ List of project reports and other deliverables with schedule.

First, a draft of the plan was prepared in consultation with the project team members and submitted to DOE for review and approval. A kickoff meeting was held at METC offices in Morgantown, VA, on 15 November 1994, where questions and clarifications regarding the draft work plan were discussed. A final work plan, incorporating the comments of the DOE COR, was prepared and submitted on 2 December 1994.

4.2 Slag Sample Selection and Procurement

Task 1.2, Production of Lightweight Aggregates from Slag, started on schedule. The first activity was to select the two project slag samples (primary and secondary slag). The following criteria were used for selection of the primary project slag:

- ▶ The suitability of its expansion characteristics based on previous work should be confirmed.
- ▶ Source should be a major U.S. coal that is amenable to gasification.
- ▶ Sufficient quantities of the slag should be available at the start of the project.
- ▶ If collected from a storage stockpile, the sample should be from a single gasifier feed rather than mixed with slags from other test coals.
- ▶ One of the two slags should be derived from an Illinois coal feed.

Based on these criteria, the potential sources of the project slag sample and their availability were identified as follows:

- ▶ Slag stockpile at TVA's National Fertilizer Development Corporation (NFDC), located at Muscle Shoals, AL.
- ▶ Tennessee Eastman Texaco gasification facility located at Kingsport, TN, which is currently in operation.
- ▶ Texaco Montebello gasification R&D facility. A small sample will be made available from their storage.
- ▶ Shell Gasifier located at Houston, TX. A small sample will be made available from their storage.
- ▶ DESTEC gasification research facility located at Plaquemine, LA. Slag samples may be available from storage, saved from earlier runs.

The Tennessee Eastman Texaco gasifier was considered to be the most viable choice as the source of the primary project slag because this is an ongoing operation and a large fresh sample could be made available for the project. Upon being briefed on the project objectives, the Eastman Chemical Company willingly agreed to participate in the project. Since this slag has not been tested previously for char removal and expansion testing, it was important to collect an advance sample to conduct preliminary tests before the bulk sample is collected. Therefore, a small (50 lb) advance shipment of slag was collected from this source and shipped to Penn State's Mineral Processing Laboratory.

4.3 Laboratory-Scale Testing

4.3.1 Slag Preparation and Char Removal

A 50-lb advance shipment of slag from Eastman Chemical Company's gasifier in Kingsport, TN, was received at Penn State in two 5-gallon buckets. The slag was prepared (Subtask 1.2.2) prior to kiln processing. Preparation consists of removing the char from the slag by tabling, followed by screening the char-free or prepared slag into size fractions that meet the feed size specifications for expanded slag products, and mechanically dewatering the prepared slag. A schematic of the slag preparation and char removal process is illustrated in Figure 1. This design was developed based on Praxis' previous work.

As can be seen, slag preparation involves preliminary screening of slag to remove coarse impurities, primarily rocks, followed by a tabling operation which selectively removes the char from the slag. The char-free slag is wet-screened into two size fractions which form the pyroprocessing feed, and the char is recovered and evaluated as a fuel. Both the char and slag are dewatered and air-dried for further use or processing.

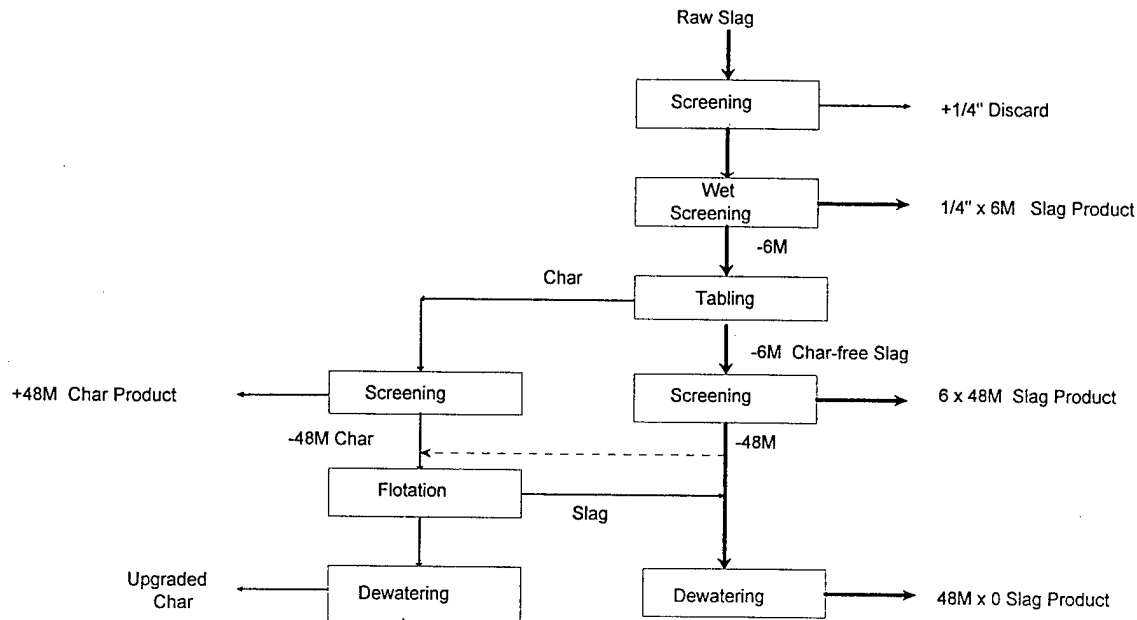


Figure 1. Slag Preparation and Char Removal

However, a slight deviation from this procedure was made for the laboratory tests on the advance sample. The sample was screened at 6 mesh instead of 1/4", because it was fresh from the gasifier and therefore did not contain rocks or other coarse impurities which are generally found in samples obtained from stockpiles.

Processing of the Eastman slag advance sample at Penn State consisted of screening followed by tabling for char removal. The sample was first wet-screened at 6 mesh using a laboratory-scale Derrick sizing screen to recover the coarse slag fraction. The minus 6-mesh fraction was remixed and fed to a laboratory-scale Deister shaking table. Preliminary table set-up was accomplished using approximately 5 lb of sample. The products from this operation were decanted, recombined, and reprocessed on the table after the table set-up was complete. Visual examination of the table operation after initial set-up suggested that collection of a middlings stream was not warranted. However, the char product was collected as two samples to verify this observation. The table was operated at a rate of approximately 400 lb/hour using a manual feeding arrangement. The table products were collected in 5-gallon containers. The samples were allowed to settle and then decanted before vacuum-filter dewatering. Each product stream was then sampled for ash analysis.

The results of the tabling run are given in Table 1. As seen from the table, the +6M fraction, which is approximately 11.1% of the feed by weight, contains no char. Therefore, this fraction did not need further processing and was set aside for kiln processing. The total slag sample had

an ash content of 85.9%. The char product extracted from this sample had a weight yield of 25.7% and an ash content of 45.1%. The ash content of each char product was similar, 43.9% vs. 47.2%, which indicates that a middlings product was not necessary. Due to this similarity, the two char products, were combined to form a single product.

Table 1. Results of Slag Processing for Char Removal

Stream	Weight %	Ash %	Comments
+ 6M	11.1	101.8	Removed before Tabling
Char Product 1	16.4	43.9	Combined to form Char w/ 45.1% Ash
Char Product 2	9.3	47.2	
Slag Products (3&4)	63.2	100.2	71.1% Slag Yield
Whole Slag	100	86.1	

The slag product was essentially free of char as indicated by the ash measurement of over 100%. Figure 2 illustrates the material balances around the screening and tabling operation. The slag product was initially collected in two streams, i.e., 3 and 4, but on observing the similarity in their composition (ash), they were combined into a single product, as shown in Table 1.

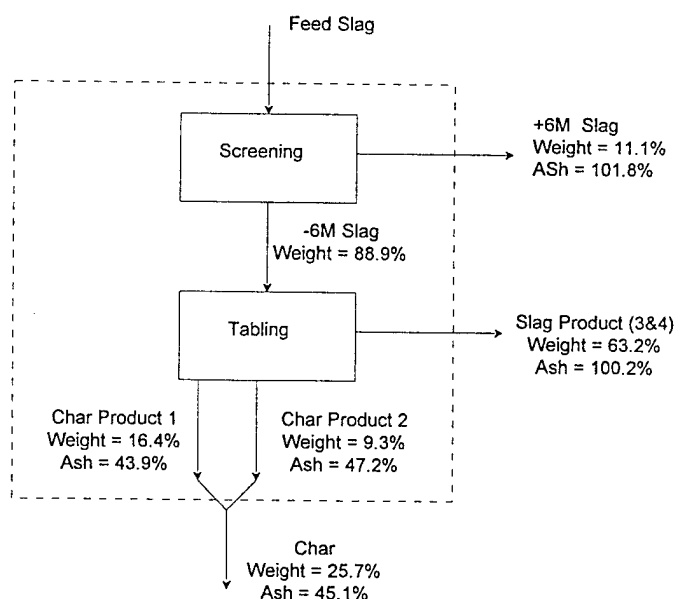


Figure 2. Material Balances around Screening/Tabling

The particle size distribution of the feed slag is shown in Table 2. The screen analysis of the slag and combined char products (1 & 2) shown in the table illustrate two important aspects of slag processing. First, the char material is similar in size to the coal grind used for the gasifier and is less than 14 mesh in size. Second, the tabling process size classifies the raw slag during processing, with the minus 65-mesh fines reporting to the char (note that only 7.88% of the slag product is minus 65 mesh).

Table 2. Particle Size Distribution of Slag

Size Fraction	Slag (Weight %)	Char (Weight %)
6M x 8M	22.96	0.00
8M x 10M	24.95	0.03
10M x 14M	18.06	0.18
14M x 20M	10.40	1.02
20M x 28M	5.24	3.39
28M x 35M	2.54	4.96
35M x 48M	4.64	24.92
48M x 65M	3.33	25.88
-65M	7.88	39.62
Total	100.00	100.00

To further clarify the fines classification, the combined char product was screened at 65 mesh and analyzed for ash content. The analysis of the two char products is presented in Table 3. The results show that the table was effective in separating char and slag for the +65 mesh fraction, since the ash content was only 28.9%. However, the minus 65-mesh fines had a very high ash content (68.1%) which confirms that fine slag is not recovered to the slag product. Therefore, the use of froth flotation techniques will be considered to clean the minus 65-mesh fines in the case of this slag.

Table 3. Char Analyses

Char	Weight %	Ash %
+65M fraction	60.38	28.9
-65M fraction	39.62	68.1
Total	100	44.4

4.3.2 Drying and Pyroprocessing

The slag samples (both the +6M and minus 6M x 0 fractions) were sealed in 5-gallon buckets after dewatering in a vacuum filter and shipped to Fuller and Silbrico for laboratory-scale slag expansion tests. The laboratory-scale test work is scheduled to commence on 14 December 1994.

5.0 PLAN FOR THE NEXT QUARTER

The following activities are planned for the next quarter:

- ▶ Laboratory-scale pyroprocessing using the Eastman slag advance sample will be completed.
- ▶ An advance sample of the secondary slag will be tested.
- ▶ Based on the outcome of advance sample testing, sources of the primary and secondary slag will be selected.
- ▶ Slag samples will be collected and shipped to Penn State for preparation
- ▶ Material balance calculations will be completed for each slag based on the results of advance sample testing.
- ▶ Development of economic analysis tools will be initiated.
- ▶ Preparation of the primary slag sample will begin at Penn State.

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